

84–92 wt%) and the third (CD), the highest rank coals (C: 92–97 wt%), tending to end up linearly at the point for graphite. Attention is drawn to the one-to-one correspondence of the above thermochemical paths with what had been observed earlier in the 'genetic path' of coal, traced out from a plot of atomic H/C' ratio versus rank for the same range and types of coals, showing the same three linear steps, demarcated by the same two turning points. The Q versus (C + H) relationship is considered more significant because of its direct relevance to the C-H matrix of coal and its progressive structural change as shown by the sequential changes of its atomic H/C' ratio. Such interpolation of the thermochemical and genetic paths has led to the development of the following novel correlation, holding good from lignite to anthracite: $Q(\text{MJ/kg}) = 0.512(\text{C} + \text{H}) - 11.19 + 6.75(\text{H/C}' - 0.78)$ which, in turn, simplifies to equation (7): $Q = 0.512(\text{C} + \text{H}) + 81.07 \text{ H/C} - 16.46$, with atomic H/C' ratio replaced by its weight ratio (H/C). Parallel correlation have also been developed based on Q versus C or Q versus O relationships but the Q versus (C + H) has been found to be the most accurate, and is recommended for general use. Allowing for contributions of heat due to S and mineral-matter (MM) transformation to ash, it has also been possible to logically deduce a derivative (Eq. (8)) giving calorific value on dry basis, directly from dry coal data: $Q_d = 0.512(\text{C}_d + \text{H}_d) + (81.07 \text{ H}_d + \text{C}_d - 16.46) \times (100 - \text{MM})/100 + 12 \text{ S}_d - 0.007 \text{ Ash}_d$. The 'genetic' correlations have been found to apply excellently well to all coals irrespective of their rank, region and variable petrographic composition, predicted values seldom deviating from experimental values by more than 0.5%. Its (Eq. (8)) potential accuracy is likely to be far better as assessed from a special test conducted on US coals. The success of the newly found correlations, is attributed mainly to the role of its H/C term

00/00489 Thermodynamic irreversibilities and second law analysis in a spray combustion process

Datta, A. Som, S. K. *Combust. Sci. Technol.*, 1999, 142, (1–6), 29–54. A theoretical model of exergy analysis, based on availability transfer and flow availability, in the process of spray combustion was developed to evaluate the total thermodynamic irreversibility and second law efficiency of the process at various operating conditions. The velocity, temperature and concentration fields in the combustor, required for the evaluation of the availabilities and irreversibilities, were computed numerically from a two phase separated flow model of the spray along with a suitable reaction kinetics for the gas phase reaction. The thermodynamic irreversibilities associated with the gas phase processes in the combustor were obtained from the entropy transport equation, while that due to the interphase transport processes were obtained as a difference of gas phase irreversibilities from the total irreversibility. The thermodynamic irreversibilities associated with different processes and a comparative picture of the variation of second law efficiency at various operating conditions were carried out to shed light on the trade-off between the effectiveness of combustion and the work lost in a spray combustion process.

10 ENGINES

Power generation and propulsion, electrical vehicles

00/00490 Automotive crankcase oils

Lakes, S. C. *Chem. Ind.*, 1998, 77, 441–459.

Automotive crankcase oils are reviewed in this paper. Specific areas discussed include engine oil applications, performance requirements for engine oils, requirements for gasoline and diesel engine oils, historic aspects of synthetic engine oils and types of synthetics and their performance in the market-place.

00/00491 Development of mobile, on-site engine coolant recycling utilizing reverse-osmosis technology

Kughn, W. and Eaton, E.R. *ASTM spec. Tech. Publ.*, 1999, 261–269. The review presents the history of the development of self-contained, mobile, high-volume, engine coolant recycling utilizing reverse-osmosis (R/O) technology. It explains the reasons behind government regulatory agencies deciding to minimize the liability of waste generators, which produce waste engine coolant by permitting an engine coolant recycling service at the customer's location. If the engine coolant is recycled at the point of origin, the generators' exposure to documentation requirements, financial burdens and liability are minimized by greatly reducing the volume of used coolant that must be hauled from

the generator's property. It describes the inherent difficulties of recycling such a highly contaminated, inconsistent input stream, such as used engine coolant, by reverse-osmosis. The paper reports how the difficulties were addressed and documents the state of the art in mobile R/O technology. Reverse-osmosis provides a purified intermediate fluid that is reinhibited for use in automotive cooling systems. The paper offers a review of experiences in various automotive applications, including light-duty, medium-duty and heavy-duty vehicles operating on many types of fuel. In conclusion, it has been noted that mobile embodiments of R/O coolant recycling technology provide finished coolants that perform equally well as new coolants as demonstrated by their ability to protect vehicles from cooling system related problems such as corrosion damage and freezing.

00/00492 Experimental instantaneous heat fluxes in the cylinder head and exhaust manifold of an air-cooled diesel engine

Rakopoulos, C. D. and Mavropoulos, G. C. *Energy Convers. Manage.*, 2000, 41, (12), 1265–1281.

An experimental analysis is performed to study the instantaneous heat fluxes, during the engine cycle, in the combustion chamber walls of a direct injection (DI), air cooled, four stroke, Diesel engine. For this purpose, a novel experimental installation has been developed, which separates the engine transient temperature signals into two parts, namely the 'long' and the 'short' term response ones, followed by their discrete processing in two independent data acquisition systems. Furthermore, a new pre-amplification unit for fast response thermocouples, appropriate heat flux sensors and an innovative, object oriented, control code for fast data acquisition have been designed and developed for the needs of the study. One dimensional heat conduction with Fourier analysis of the raw temperature data are implemented in order to calculate the instantaneous engine cylinder and exhaust pipe heat fluxes. Analysis of the experimental results reveal many interesting aspects of transient engine heat transfer. The effect of engine speed on cylinder head and exhaust manifold heat losses is presented. The simultaneous presentation of heat fluxes on the cylinder head and exhaust manifold, together with the engine indicator diagram, sheds light into the mechanisms governing the transient heat transfer. This is very important, since especially for air cooled Diesel engines, limited information seems to exist in the relevant literature.

00/00493 Gas cleaning for IC engine applications from fixed bed biomass gasification

Hasler, P. and Nussbaumer, T. *Biomass Bioenergy*, 1999, 16, (6), 385–395.

Gas cleaning for tar and particle removal is vital for internal combustion (IC) engine applications of producer gas from fixed bed biomass gasifiers, which are usually in the capacity range from 100 kW up to 5000 kW. In the present investigation, tar and particle collection efficiencies have been detected in a sand bed filter, a wash tower, two different fabric filters and a rotational particle separator in different test runs with fixed bed gasifiers. Tar adsorption on coke has been studied in a fixed bed batch reactor. Furthermore, data from literature for catalytic tar crackers, venturi scrubbers, a rotational atomizer and a wet electrostatic precipitator (ESP) are provided. Based on the presented gas cleaning efficiencies and the investment cost, an assessment of gas cleaning systems is made for IC engine applications from cocurrent gasifiers. The postulated gas quality requirements for IC engines cannot be safely achieved with state-of-the-art gas cleaning techniques and that 90% particle removal is easier to achieve than 90% tar removal. Except for the catalytic tar crackers that are considered as an option for applications above several MW and for gases with a high tar level, none of the investigated gas cleaning systems can securely meet a tar reduction exceeding 90%. Therefore one of the key issues for a successful application of biomass derived producer gas from small scale gasifiers is the removal of tar, where further development is required.

00/00494 Influence of the ambient temperature on the operational indices of the gas turbine set

Szargut, J. *Int. J. Energy Res.*, 2000, 24, (9), 821–830.

Applying the volumetric characteristics of the compressor and the equation of Stodola, formulae have been developed expressing the influence of the changes of ambient temperature on the mass output of the compressor and compression ratio in the set of gas turbine. Influence on the mechanical power and energy efficiency of the set as well as on the thermal power of the waste heat boiler has been determined too.

00/00495 Latest information about Stirling engines. The present state of development and chances for the future

Beck, P. *Brennst.-Waerme-Kraft*, 1999, 51, (9), 38–41. (In German) In Stirling engines a constant amount of gas is compressed and expanded cyclically, therefore, owing to thermodynamic laws, this work could be used for the generation of power. In refrigerating systems, this

engine can also be used. As primary fuels to drive the Stirling engines biomass, disposal gas, biogas, and solar energy are presented. A discussion is also included on the possible utilization of Sterling engines in vehicles and the future demand in research and development of this technology is presented.

00/00496 Optimum performance of a heat engine-driven combined vapour compression-absorption-ejector heat pump

Göktun, S. and Bayülken, A. *Int. J. Energy Res.*, 2000, 24, (8), 655–664. Optimum performance of an endoreversible heat engine-driven heat pump cycle, based on a combination of an absorption cycle with a vapour and ejector compression cycles is investigated. This combination increases the performance of the conventional ejector and absorption cycles and provides high performance for heating. The analysis shows that the combined heat pump cycle has a significant increase in system performance over the heat engine-driven vapour compression or absorption heat pump cycle and heat engine-driven combined vapour compression and absorption heat pump cycle.

00/00497 Preheating apparatus of gasification furnace

Konishi, S. and Hori, T. *Jpn. Kokai Tokkyo Koho JP 11 228,975 [99 228,975]* (Cl. C10J3/46), 24 Aug 1999, Appl. 1998/31,576, 13 Feb 1998. 4. (In Japanese)

The preheating apparatus of a downward entrained-bed type gasifier is described. The process involves gasification of a carbonaceous fuel, such as coal with oxidizing agent and water by downward injection from the top of the gasifier main body. The reason behind this is the reaction comprises of preheating burners located downstream of the gasifier main body for heating the inside of the gasifier main body.

00/00498 Prevention of waste oils generation from diesel engines

Sumimoto, M. *Jpn. Kokai Tokkyo Koho JP 11 257,038 [99 257,038]* (Cl. F01M1/10), 21 Sep 1999, Appl. 1998/87,978, 17 Mar 1998. 9. (In Japanese)

A method for preventing the generation of waste oils from diesel engines, such as power-generation equipment is described. The process involves flushing the internal part of the diesel engine with an agent, containing surfactant dissolved in water, mixing it with a lubricating oil, passing the lubricating oil through parallel interlayer intervals stacked by a plurality of thin papers, removing $> 1 \mu\text{m}$ impurities of the lubricating oil deposited on the paper fibres and filtering the lubricating oil with a filter element to remove $1 \mu\text{m}$ finer impurities in the lubricating oil. The final stages of the method involve removing the fuel oil impurities using a filtration step and improving the combustion efficiency by making fine particles of the fuel oil and taking out the supernatant from the fuel tank.

00/00499 Retardation of spontaneous hydrocarbon ignition in diesel engines by Di-tert-butyl Peroxide

Clothier, P. Q. E. *et al. Combustion and Flame*, 2000, 121, (4), 689–694.

Di-tert-butyl peroxide is a well-known accelerant for spontaneous ignition of practical fuels in a diesel engine. It has been discovered, however, that it retards the spontaneous ignition of pure hydrocarbon fuels in an engine under simulated cold-starting conditions. This paper reports on modelling calculations which suggest why di-tert-butyl peroxide could inhibit the spontaneous ignition of *n*-hexadecane and on experiments designed to elucidate the mechanisms by which this peroxide works as an ignition improver in commercial fuels. It appears that di-tert-butyl peroxide neutralizes the inhibiting effects of some naturally present amines in the hot fuel spray droplets.

00/00500 Semi-closed gas turbine unit run on solid fuel

Mikhaltsev, V.E. *et al. Vestn. Mosk. Gos. Tekh. Univ., Ser. 'Mashinost.'*, 1999, 1, 75–84. (In Russian)

The analysis of a prospective gas turbine power unit over a wide range of power both in mobile and stationary modifications is covered in this paper. Non-traditional and renewable fuels of high efficiency are used in the unit.

00/00501 Streamtube model for analysis of vertical axis variable pitch turbine for marine currents energy conversion

Camporeale, S. M. and Magi, V. *Energy Convers. Manage.*, 2000, 41, (15), 1811–1827.

Marine currents may represent a renewable energy source characterized by a limited environmental impact. In Italy, the Strait of Messina seems to be suited for exploitation of this energy source. A vertical axis turbine, with blades oscillating about the pivotal axis according to the Voith-Schneider system, has been considered. This paper presents a preliminary theoretical investigation of the performance of this kind of turbine that may be employed to tap marine currents energy sources. The investigation is conducted by means of a simple momentum model based on the 'single-disk single-streamtube' approach. The theoretical

results are compared with experimental measurements. The adequate agreement between experimental and theoretical results shows that such a simple model may be able to predict the power coefficient and the operating range of the turbine.

00/00502 The investigation on flash boiling fuel spray and combustion in diesel engine

Duan, S. *et al. Proc. Int. Conf. Intern. Combust. Engines*, 1997, 197–201. Edited by Zhu M., Zhang Y.

The regulation of droplets distribution of flash boiling spray is investigated by use of laser holography. The mean diameter of the fuel droplets of flash boiling spray are smaller and more homogenous in comparison with conventional spray in axial and radial. In a single cylinder diesel engine, the experimental study of combustion characteristics of flash boiling spray is performed with diesel fuel and coal liquid. The smoke emission and BSFC of flash boiling fuel spray combustion style is dramatically lower at high load comparing with that of conventional style. The test results of coal liquid combustion in a diesel engine show that the use of low cetane number fuels demonstrate great potential in diesel engines with flash boiling fuel spray and combustion style.

00/00503 Thermal balance of a single cylinder diesel engine operating on alternative fuels

Ajav, E.A. *et al. Energy Convers. Manage.*, 2000, 41, (14), 1533–1541.

The thermal balance of a constant speed stationary compression ignition engine operating on diesel, ethanol-diesel blends and fumigated ethanol was established at different loading conditions of the engine. The thermal balance was in respect of useful work, heat lost to cooling water, heat lost through exhaust, heat carried away by the lubricating oil and other losses (unaccounted-for losses). The results indicate that the thermal balance of the engine operating on 5 and 10% ethanol-diesel blends and fumigated ethanol was not significantly different at the 5% level of significance when compared to diesel. However, in the case of 15 and 20% ethanol-diesel blends, the thermal balance was significantly different compared to diesel.

11 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

00/00504 A second law approach to compact surface performance analysis

Hesselgreaves, J. E. *Imech. Conf. Trans.*, 1999, , 45–52.

The entropy production rate of a heat exchanger surface is controlled by an expected heating rate, the temperature difference and geometric parameters. An analysis of the local entropy generation rate showed that, if the ratio of friction factor (*f*) to heat transfer (*j*) factor was independent of Reynolds number, *Re*, the temperature difference and pressure drop components of the entropy production were equal, the optimum generation rate being proportional to the inverse of flow area. The present paper develops the analysis for a general surface in which *f/j* is a function of *Re*, showing that the minimum generation rate is little affected by practical variations in surface performance. This paper provides an example of a typical comparison of the simple and more general approaches.

00/00505 Applicability of chemical absorption process to carbon dioxide removal and recovery under effluent gas conditions of coal-fired power plant

Mimura, T. *et al. Kagaku Kogaku Ronbunshu*, 2000, 26, (1), 6–10. (In Japanese)

This paper describes an investigation into the applicability of the chemical absorption process to carbon dioxide removal and recovery under effluent gas conditions equivalent to those for coal-fired power plants. In the pilot plant test, KS-3 absorbent was used at an exhaust gas flow rate of 450 m³/h, overall performance of the system was confirmed by approximately 200 h' operation with 50 ppm coexisting SO_x, that longer operation is permitted, judging from the experimental evidence of KS-3 corrosion properties under coal-fired conditions in comparison with LNG-fired power plants.